Chip-Scale Active Fast Light Gyroscope and Accelerometer using Integrated Photonic Technology, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

The fast-light effect in a cavity, in the active or passive mode, has emerged as an important mechanism for enhancing the sensitivity of many devices. Recently, we have been investigating the development of gyroscopes and accelerometers using the active mode, in which the cavity is a Fast-Light Ring Laser (FLRL). Specifically, we have demonstrated, on a table-top, a pair of counter-propagating FLRL's, with one of the cavity mirrors mounted on a metallic diaphragm, thus realizing an Active Fast Light Gyroscope and Accelerometer (AFLOGA). In this system, the anomalously dispersive gain is produced by a pair of Rb vapor cells, each containing two isotopes of Rb. We have seen an enhancement in sensitivity by a factor of nearly three orders of magnitude. In order to increase the sensitivity further, and demonstrate the corresponding improvements in the minimum measurable rates of rotation or acceleration, it is necessary to achieve quantum noise limited operation, by enhancing the robustness of the system. To this end, we here propose to develop a miniature AFLOGA, using chip-scale components at Rb wavelengths of 780/795 nm. The components include lasers, modulators, detectors, waveguides, and optical isolators, integrated on a single chip. GaAsP Quantum Wells (QWs) will enable the realization of the active photonic components. In sections for the passive components, the QWs would be disordered to minimize optical losses. A resonator containing two miniature vapor cells will be used as the cavity for the two FLRLs. The chip-mounted components will be interconnected with the cavity, as well as additional electronics on a printed circuit board. In Phase I, we will develop a detailed design of the chip-scale AFLOGA and demonstrate functionality of key components. In Phase II, we will demonstrate operation of an AFLOGA with a million-fold improvement in precision, and then use copies thereof to demonstrate a three-axes Fast-Light Inertial Measurement Unit (FLIMU).

Anticipated Benefits

• Improved space vehicle positioning and navigation

• Space vehicle health monitoring

• Gravitational mapping of subsurface geologic features

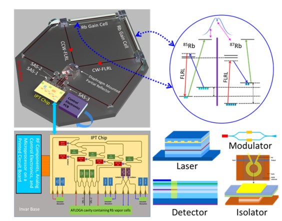
• Gravity wave (which is different from gravitational wave) detection

• Ultra-precise pointing and platform stabilization for telescopes

• Tests of general relativity via measurement of gravitational frame dragging effect

• Improved positioning and navigation of missiles

• Positioning and navigation for atmospheric and ground vehicles in GPS-denied environments



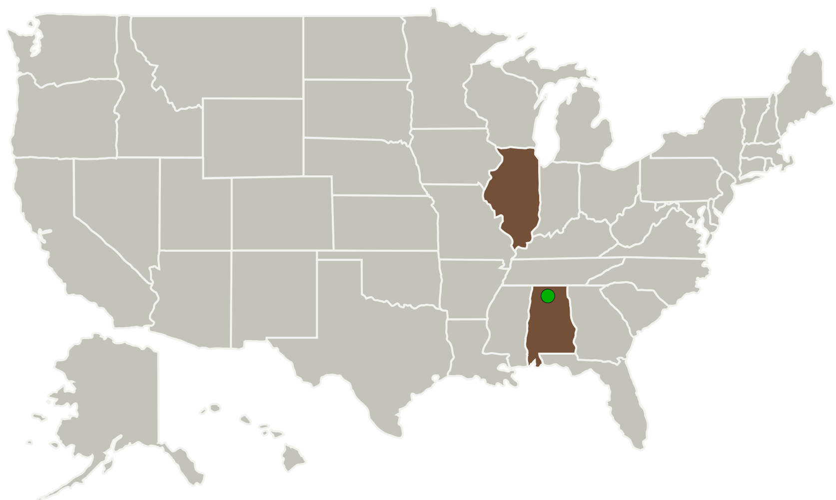
Chip-Scale Active Fast Light Gyroscope and Accelerometer using Integrated Photonic Technology, Phase I

Table of Contents

Project Introduction	1
Anticipated Benefits	1
Primary U.S. Work Locations and Key Partners	2
Organizational Responsibility	2
Project Management	2
Technology Maturity (TRL)	2
Project Transitions	3
Images	3
Technology Areas	3
Target Destinations	3

- Guidance of unmanned underwater vehicles (UUVs)
- Guidance of smart ammunitions
- Vibration sensors for seismometry and nuclear non-proliferation
- Advanced laser beam pointing/steering systems

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Digital Optics Technologies, Inc.	Lead Organization	Industry	Rolling Meadows, Illinois
Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations	
Alabama	Illinois

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Digital Optics Technologies, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

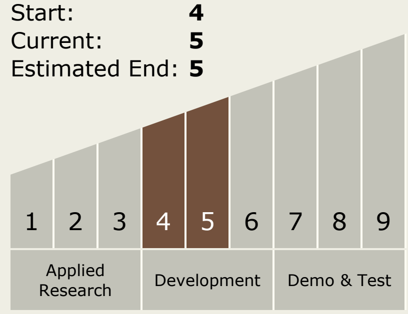
Carlos Torrez

Principal Investigator:

Shih Tseng

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



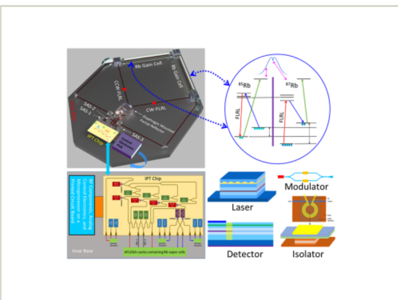
Project Transitions

July 2018: Project Start

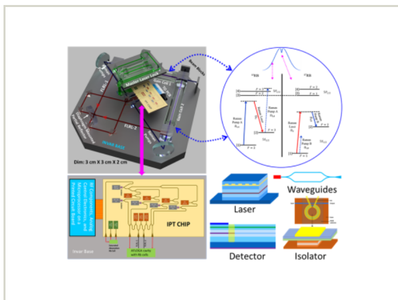
February 2019: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/141303)*

Images



Briefing Chart Image
Chip-Scale Active Fast Light Gyroscope and Accelerometer using Integrated Photonic Technology, Phase I
(https://techport.nasa.gov/image/126880)



Final Summary Chart Image
Chip-Scale Active Fast Light Gyroscope and Accelerometer using Integrated Photonic Technology, Phase I
(https://techport.nasa.gov/image/126845)

Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - └ TX05.4 Network Provided Position, Navigation, and Timing
    - └ TX05.4.2 Revolutionary Position, Navigation, and Timing Technologies

Target Destinations

Earth, The Moon, Mars